Investigating the Use of Energy and Water in Villages in the East Mesuji region of Sumatra, Indonesia

Ahmad Taufik and Jonathan Whale

Abstract—Lampung, Sumatra is one of the targeted areas of the millennium development goal (MDG) in Indonesia, particularly related issues on energy and healthy water. The aim of this paper is to look at the impact of programs related to drinking water and renewable energy projects on two villages in the East Mesuji region of Lampung through field observations (conducted in the villages of Tanjung Menang and Tanjung Mas Malanur) and interview. The interviews were given to community leaders in the village of Tanjung Menang. The results show that both villages have continuing problems in regard to poor water quality, sanitation, short energy supplies, and environmental degradation. The renewable energy projects were not successful due to a variety of issues including ownership, overestimating usage and underestimating affordability, use of the technology for applications that it was not designed for and lack of adequate training for the villagers.

Keywords—Energy and water use, environmental degradation, renewable energy technology, sanitation.

I. INTRODUCTION

Since the 1960's to 1980s the national Department of Transmigration in Indonesia has operated a transmigration program that was designed to improve the economic life of communities in areas of highest population density (predominantly Javan Island [1-2]) by resettling communities in rural areas on other islands. In the 1970s, the transmigration program targeted three main islands of Sumatera, Borneo and Papua as locations for resettlement due to the islands containing areas of low population density and large areas of rain forest [3]. Out of the 903 new villages established under the transmigration program, many have experienced problems such as deforestation leading to high salinity, lack of electricity and water supply systems and poor sanitation. Combined with limited access to health services and a low level of education this has resulted in a severe seasonal spread of disease [4-9]. Transmigration of people from different ethnic backgrounds to the same village has also led to ethnic clashes in some villages [10-11].

An example of an area where many “transmigration” villages were established in Sumatra is the East Mesuji region, located in the district of Tulang Bawang in the province of Lampung. The deforestation has been so intense in this district that today the rain forest is one tenth of the size that it was before the policy of transmigration [12]. The villages in the Tulang Bawang district have one of the highest rates of incidence of water-borne diseases in Lampung [13-15]. Moreover, for the East Mesuji region only, it was reported that more than 124 villages are not equipped with basic facilities such as electricity and water supply systems for over 29 years [16].

The seriousness of the plight of villagers in the transmigration villages in Lampung has prompted action from both government departments and non-government organizations. Over a period from 1990 to 2006 the Lampung government supported programs to improve community health in rural areas through sanitation program [17]. At both national and provincial level, government departments have also supported programs related to improving energy services to rural areas through the installation of renewable energy technology. In the East Mesuji area, a key project was the 2007 development, in the village of Tanjung Mas Malanur (Latitude: 3°45' - 4°05'; Longitude: 105°07' - 105°38'), of a multi-billion rupiah commercial mall featuring the demonstration of photovoltaic (PV) technology for business premises and public facilities. Non-government initiatives have resulted in a small number of stand-alone solar home systems installed within villages in the area [18-19].

Non-government organizations have also been active in trying to address the problems experienced in the transmigration villages. A key organization working in the East Mesuji is the Yayasan Pijar Cendekiantan Foundation (YPC), based in Bandar Lampung. In 2001 the YPC, with financial support from GTZ, initiated a long-term research project aimed at improving agricultural productivity and reduce the spread of diseases in the villages by the use of wind-driven mechanical water pumping system, referred to as the PKM. Traditional farmers from the area were involved in the design to manufacturing stages of the wind pump [20].

In 2005 a demonstration project of the wind pump was installed in the village of Tanjung Menang (Latitude of 4°00' - 4°15'; Longitude of 105°15' - 105°30'), one of the
transmigration villages in the East Mesuji region of Lampung (see Fig. 1). The Tanjung Menang village is noted for having the highest number of ethnic groups (two) of any village in the East Mesuji. The village is also one of the central villages in the transmigration villages either side of the provincial boundaries of the provinces of Lampung and South Sumatra. The VPC established research stations in Tanjung Menang and observed that the PKM requires further development in order to meet the growth in demand for water for the villagers. The VPC has obtained further research grants to develop the PKM and to undertake research in other villages in the area [21].

The aim of this work is to investigate the impact of government and NGO programs related to drinking water and renewable energy in the villages of Tanjung Menang and Tanjung Mas Makmur in the East Mesuji region. The scope of work for the paper was defined by the following objects, namely: (1) to ascertain the conditions within the villages with regard to energy, water, sanitation and public facilities; (2) to investigate the performance of the NGO wind pump project in Tanjung Menang; (3) to investigate the performance of the PV demonstration project in Tanjung Mas Makmur; and (4) to gauge the opinion of the community leaders of Tanjung Menang on the issue of water, energy and technology within the village.

A. Field Observation

Assessing the conditions within the villages was carried out by field observations. The main objectives of the field observation in Tanjung Menang was to observe public facilities, energy usage, fuel prices, water resources, water supply systems, and installed renewable energy technologies. The main objective of the field observation in Tanjung Mas Makmur was to investigate the PV lighting systems for commercial premises and for public facilities (road light, water supply systems and monopole light) as well as the water treatment station.

B. Interview

Gauging the opinion of community leaders of Tanjung Menang on key issues was carried out by semi-structured interviews. Local village culture dictates that community leaders must satisfy certain criteria related to their experience and dedication to the village. For the interviews, 25 participants were selected in terms of their position, influence and reputation within the Tanjung Menang village. The interview materials were structured in terms of six general areas of questioning, namely:

1. questions on background/context: typical questions included length of stay in the village and experience as a community leader
2. questions on opinions regarding drinking water: typical questions included sources of drinking water, concerns about water resources, opinions about water quality and expectations of government programs on water supply systems
3. questions on opinions regarding energy: typical questions included opinions about energy availability and prices, current condition of energy and fuel services and expectations of programs on energy supply systems
4. questions on how technology is viewed in the village: typical questions related to concepts of technological advancement, technological impact and opinions on sustainable development
5. questions on renewable energy projects: typical questions included experiences with renewable energy technologies, lessons learnt from demonstration projects and appropriate technologies and sites for renewable energy projects within the village
6. The ideas about giving priority scale for future development of the Tanjung Menang village.

The interview was initiated by sending an official letter of introduction to the headman of the Tanjung Menang village. The headman of the village informed the community leaders about the proposed interview at an open forum and approval was given by the community leaders. The interviews were carried out by surveyors at the participants’ homes from 24th August 2009 to 24th September 2009.

III. RESULTS

A. Field Observation

In terms of general observations on the public facilities in the villages Tanjung Menang and Tanjung Mas Makmur, both villages have limited access to roads, schools and health facilities. The PKM has not had purpose built supply systems for electricity and water. In comparison, the Tanjung Mas Makmur village does have a water supply system, which opened to the public in 2007. During the field observations it became apparent that the system has not worked properly for some time, and failed to distribute water to the villagers. The water intake from the Kualo Menang river was very limited and had built up in the water tank and blocked the intake pipe (see Fig. 4). The water tank itself was not maintained well and it was observed that the water had an unpleasant odor and, after sediment had settled, was green in color.

Fig. 4 Water supply station in the Tanjung Mas Makmur: (a) intake gate of water supply system; (b) electrical-DC water pumping; and (c) output water pool.

In investigating the performance of the NGO wind pump (PKM) project in Tanjung Menang, it was discovered that the PKM had failed to survive through a combination of lack of maintenance and vandalism. Four main components of the system were found to be in a rusted condition including the tower, which was rusted. In the past, water users could rely on the wind pump. It is likely that the vandalism occurred in order to prevent this and could participate in maintaining the wind pump. It is predicted that the vandalism occurred in order to prevent this and could participate in maintaining the wind pump. It is predicted that the vandalism occurred in order to prevent this and could participate in maintaining the wind pump. It is predicted that the vandalism occurred in order to prevent this and could participate in maintaining the wind pump.
For the Tanjung Mas Makmur (the KTM project), worst condition also happened. Numerous PV panels failed to survive; only some of PV panels for road lighting were still working. PV for mall light and kiosks of modern market were not working since none of villagers could afford high rental prices of the kiosks in the market and the mall as shown in Fig. 6. As previously mentioned, PV for water supply also did not work to distribute water to villagers.

B. Interview

1) Water Quality

There are at least 15 types of independent and dependent organizations structure, which influence the village development. The participants have adequate experiences and a significant staying duration in the Tanjung Menang village (Table 1).

Table 1. General characteristics of the selected participants

<table>
<thead>
<tr>
<th>Position in the Community</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leader of Youth Organization</td>
<td>22</td>
</tr>
<tr>
<td>Village Security</td>
<td>20</td>
</tr>
<tr>
<td>Coordinator of Primary School Teacher</td>
<td>9</td>
</tr>
<tr>
<td>Youth Representative Village Board Meeting</td>
<td>7</td>
</tr>
<tr>
<td>Member of Village Board Meeting</td>
<td>55</td>
</tr>
<tr>
<td>Business Association-shopkeeper</td>
<td>14</td>
</tr>
<tr>
<td>Leader of Islamic Council</td>
<td>13</td>
</tr>
<tr>
<td>Member of Village Board Meeting - Accommodation</td>
<td>3</td>
</tr>
<tr>
<td>Member of Business Association-electricity supplier</td>
<td>4</td>
</tr>
<tr>
<td>Teacher</td>
<td>19</td>
</tr>
<tr>
<td>Secretary of Youth Organization</td>
<td>8</td>
</tr>
<tr>
<td>Labor Coordinator of Public Society</td>
<td>14</td>
</tr>
<tr>
<td>Member of Village Board Meeting-Cultural committee</td>
<td>14</td>
</tr>
<tr>
<td>Founder of private middle school</td>
<td>14</td>
</tr>
<tr>
<td>Leader - Traditional planning</td>
<td>12</td>
</tr>
<tr>
<td>Leader - Traditional religion</td>
<td>6</td>
</tr>
<tr>
<td>Chief coordinator of Transportation association</td>
<td>24</td>
</tr>
<tr>
<td>Village Nurse - Government Nursery Representative</td>
<td>10</td>
</tr>
<tr>
<td>Truck owner</td>
<td>6</td>
</tr>
<tr>
<td>Merchant/leader</td>
<td>5</td>
</tr>
<tr>
<td>Leader of Women Trade Association</td>
<td>2</td>
</tr>
<tr>
<td>Leader of Village Nature Organization</td>
<td>3</td>
</tr>
<tr>
<td>Leader of Village Trade Association</td>
<td>5</td>
</tr>
<tr>
<td>Leader of Private Trade Association</td>
<td>5</td>
</tr>
<tr>
<td>Leader of Village School Teacher</td>
<td>8</td>
</tr>
<tr>
<td>Village midwife</td>
<td>14</td>
</tr>
</tbody>
</table>

Note: P is participant. It is a number of years in current position, 1. It is a number of years residing in the Tanjung Menang Village.

It has been observed that majority of the villagers have consumed water in their wells for long period of time such as from 10-20 years. It was indicated that the some community leaders have attempted to find the better water resource for drinking, by providing another new wells near their house, or even at their son's houses. The first well at the villagers house was provided by Transmigrasi Department through Indonesian transmigration program (3).

The shortest duration of consuming water from the first well was indicated by one community leader who has consumed water for 2 years. Then, he/she attempted to dig a second well. It was indicated that he/she used the second well a lot longer, 8 years. The longest duration of consuming water from the first well was indicated by one community leader who has consumed water for 24 years. There were observed that 4 community leaders who used water for long time 20 to 29 years. However, the community leader did not specify from which well they consumed water.

Table 2. Duration of consuming water

<table>
<thead>
<tr>
<th>Years of consuming water</th>
<th>NP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 years consuming water from first well, 6 years from second well</td>
<td>1</td>
</tr>
<tr>
<td>2 years consuming water from first well, 5 years from second well</td>
<td>1</td>
</tr>
<tr>
<td>2 years consuming water from first well, 4 years from second well</td>
<td>1</td>
</tr>
<tr>
<td>2 years consuming water from first well, 3 years from second well</td>
<td>1</td>
</tr>
<tr>
<td>2 years consuming water from first well, 2 years from second well</td>
<td>1</td>
</tr>
<tr>
<td>2 years consuming water from first well, 1 year from second well</td>
<td>1</td>
</tr>
<tr>
<td>2 years consuming water from first well</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: NP stands for number of participant respond to the question of interview.

2) 2 community leaders thought that better water quality for drinking water is the same with rain water. Therefore, it was found that numbers of water tanks at villagers' house for collecting rain water.

3) 4 community leaders have pointed out that better water quality for drinking is the same with bottled water.

4) 2 community leaders have tried to filter water from the well. They put natural-local water filtration material outside of the well's ring. Better water absorbed to the well.

5) 2 community leaders estimated that water quality was also significantly influenced by a distance between well and septic tanks.

6) 2 other community leaders stated that water resources must be regularly maintained.

7) Compare drinking water to neighboring villages. Actions of this opinion were described in point 1.

About water vulnerability, all of the community leader was seriously concerned in the following aspects, namely:

1) always happen annually in the both seasons, raining and dry season.

2) Protecting water resources, particularly for water catchment areas in the forest is urgently required.

3) Technology for water treatment must solve health problem of the Tanjung Menang village such as in the dry season, the technology can solve the main water problems (sulinity and amount of water).

5) For effects on health problems, 15 community leaders suggested to overcome spread diseases for both seasons by conducting prevention activities and education program for villagers. Moreover, 2 community leaders concerned about long term effects on health due to consuming water for long period of time.

6) All of the community leaders expected that local government of EMTB or Lampung province put more efforts on water quality, sanitation and water resources. Small target was set that Indonesian government can provide water supply station in the Tanjung Menang village.

4) Current Situation of Energy Use

All of the community leaders concerned about local problems on current situation of energy use, namely: energy shortages, energy prices including fuel prices in the Tanjung Menang, increase of electricity without an increase in electricity supplying to the villagers. Moreover, 2 community leaders concerned about long term effects on health due to consuming water for long period of time.

It was studied that there were five major areas had been identified as sources of the energy shortages, namely:

1) limited stock wood for cooking in the dry season always increase kerosene price (44%); (2) Huge demand for kerosene and diesel are also main problems for villagers (32%); (3) Water price in the dry season is other main issue for energy shortage (12%); (4) Roads and other basic infrastructures are fundamental aspects for controlling energy shortages (12%); and (5) environmental degradation is also main key factor affecting wood supply to the villagers (8%).

The increase of energy prices has put all of the villagers into a difficult economic situation. It was suggested that local...
government will consider three main targeted areas in the near future, namely: (1) Energy shortages & short supplies for basic fuels (kerosene, diesel and unleaded petrol) for both seasons (56%); (2) Improving roads to control fuel supplies and energy shortages (16%); and (3) Control demand for fuels and energy (28%).

For using alternative energy sources, it was observed that 36% of the community leaders suggested to use renewable energy resources available in the Tanjung Menang village; 20% of the community leaders still expected that local government to put on grid electricity. 24% of the community leaders suggested to use local technology for supporting the use of renewable energy resources; and the rest 12% of the community leaders expected that the use of renewable energy resources can give massive to all aspects of villagers such as water supply for irrigation, drinking water, sanitation and training-education.

Discussing current energy situation, the community leaders identified four critical aspects to be considered to improve energy situation in Tanjung Menang and surrounding villages, namely: (1) short supply fuels for both seasons need to be solved as soon as possible (48%); (2) related to a high price of diesel in the MTB areas, improving roads and public facilities are recommended (20%); (3) Proposing a similar program: the Integrated Independent Energy Village (KTM: Kota Terpadu Mandiri) is stated by 3 community leaders (12.5%); and (4) Using battery as an alternative solution since villagers previously used to had batteries for producing electricity (12%).

- Point of view on renewable energy projects
  - All community leaders stated that electricity and water supply are the most suitable application area of renewable energy technologies (RETs).
  - There were several barriers for implementing the RETs as identified by the community leaders. 6 community leaders stated that the difficulties for RE projects will be in terms of selection an appropriate technology for the Tanjung Menang village. 5 community leaders specified that the difficulties for RE projects will be in terms of operational procedure including maintenance system. 3 community leaders stated that educational background of operators is key point for RE project. Only 1 community leader pointed out that supply of the RE projects' component will be the most difficult one.
  - To maintain the RETs, 10 community leaders assessed based on ability to find and fix the RE projects' problems. 8 community leaders examined based on ability to do job similar to a mechanical workshop. 6 community leaders assessed based on ability to install and maintain the RE projects. Only 1 community leader did not put any comment on the difficulties for RE projects.

- The priority scale of development program
  - There were 8 aspects of priority scale of future development program for the Tanjung Menang village: namely: cheap energy, electricity, free of charge for education, free charge for health services, healthy water, market, medical clinic and roads. Fig. 7 indicates distribution of the aspects in terms of first to fifth order of priority scale given by community leaders. Fig. 8 shows accumulation of priority scale from the first to fifth order.
  - It is shown in Fig. 7, electricity is the highest rank in the first order of priority scale. It gradually decreases for the next order. In contrast, cheap energy and healthy water increase in the second order of priority scale. Then, only healthy water still increases in the third order of priority scale. The aspect of road, market and medical clinic gradually increase in the second to the fifth order of priority scale.
  - It is depicted in Fig. 8, four major aspects of priority scale were identified such as electricity with the value of 24, healthy water with the value of 20, cheap energy with the value of 17 and free of charge for education with the value of 16. Then, healthy water, cheap energy, market, medical clinic and roads followed the major aspects of priority scale with the value of 13, 12, 10 and 13 respectively.

IV. ANALYSIS & DISCUSSION

Water, energy, environment, technology and education are fundamental aspects to be considered for improving rural areas in the developing countries [22]. Throughout this study, there are four more fundamental aspects explored for rural areas in Indonesia, namely: free of charge for health services, tourism, medical clinic and roads.

It can be observed from Tanjung Menang and Tanjung Mas Malakun case that those fundamental aspects were not handled appropriately by local governments of the EMCTB district and Lampung province. It also means that those fundamental aspects were not becoming priority aspects for long term program.

For instance, it was reported that water map in the EMCTB areas indicated huge cover area of salinity problem [23]. This is not a new issue since previous study accomplished by Siri [24] indicated the same condition. It is predicted that salinity problem is strongly related to the EMCTB soil characteristic (majority swamp area) and massive deforestation. The massive deforestation is predicted to contribute to soil change [25-26]. Observed that rain forest in the Lampung province, which is included the EMCTB areas has significantly decreased into 10% due to land clearance for transportation program. The land clearance activities in 1970s frequently used fire, which was not only affect soil characteristic but also has introduced another problems such as massive eye irrigation and respiratory problem in other provinces (South Sumatera, Riau and some parts of Malaysia [27]).

For water quality and related areas (sanitation & environment), community leaders also indicated that there are serious demands for better water supply, educational program on sanitation and environment, improvement health services and sanitation work. The community leaders also indicated that a gap on understanding water-sanitation and environment has revealed between villagers and community leader. The villagers did not have sufficient budget and did not show strong effort to manage these conditions. It can be seen from a significant amount rubbish was dumped in the Kuala Mesuji river and ponds (see Fig 3 and Fig. 4). Moreover, the villagers would not care about the distance between their village and well and did not isolate waste water from household, which is let flowing to backyard. It is also informed through interview that local government did not intensively provide campaign and training program for the villagers.

It is also shown that villagers were easily provoked to sabotage the PPKM (see Fig. 5). This is a very critical point for implementing the RETs technology in a fragile community as discussed early by Elchanit [11]. Similar problem to the PPKM, some PV panels in the Tanjung Mas Malakun project has been stolen and destroyed. The villagers need to open their mind and the local stakeholders are intensively needed to educate and to motivate them. This interaction needs a long term commitment from all of the local stakeholders.

For overcoming water problems and environmental degradation, it has been observed that there are other big tasks for all of the stakeholders. Throughout carbon trading program [28], it is estimated that the big tasks to overcome problems can be collaborate with other government agencies, NGOs and institution.

For the use of local energy resources, it is also indicated that the villagers are still dependent on wood for cooking. Using wood for cooking for long time has worsened local forest conservation in the Tanjung Menang. Awareness from community leaders has shown through proposing re-planting trees in the Tanjung Menang forest.

For fuel prices, Indonesian government failed to control fuel prices. Fuel subsidized programs only worked in urban areas [29]. For rural areas, the fuel prices are varied and strongly dependent on geographic and transportation conditions [30].

For Tanjung Menang and Tanjung Mas Malakun condition, roads' conditions during the raining season have significantly contributed to increase of energy prices. From field observation, it was notified that transportation cost usually increases from five times higher than the transportation cost during the dry season. Consequently, this condition increase living cost and other energy sectors such as fuel prices.

However, on the dry season, the villagers are facing another
In measuring villagers’ point of view on sustainable criteria, it is indicated that in general, community leaders have well understood [32]. However, like many other villages in the developing countries as investigated by Chishiri and Higgins [33], sustainable development of villages need a strong commitment of local and national stakeholders. The electricity, fields prices and technology are key factors to improve better economics life of the villagers. The lift time of RET’s projects/products is strongly related to end users’ awareness and social aspects. Then, the commitment can be measured from rigid programs, which will be run in a medium term and be continued in the long term program.

V. CONCLUDING REMARKS AND FUTURE WORK

A. Concluding Remarks

The electricity, fields prices and technology are key factors to improve better economics life of the villagers. The lift time of RET’s projects/products is strongly related to end users’ awareness and social aspects. Then, the commitment can be measured from rigid programs, which will be run in a medium term and be continued in the long term program.

B. Future Works

Future works are required to investigate opinions about priority scale of the village to bring the priority scale of future development program of the EMIB area should be prioritized in the near future. Moreover, this program should be discussed intensively with the local government of Lampung Province and with other NGOs, government agencies and educational institutions. Then, the discussion results are proposed to provincial and national government.

Fig. 9 Satellite photo over the EMTB area

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A Practical Method for Load Balancing in the LV Distribution Networks
Case study: Tabriz electrical network

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Abstract—In this paper, a new efficient method for load balancing in low voltage distribution systems is presented. This proposed method improves an improved Leap-frog method for optimization.

By applying the proposed algorithm, the neutral current becomes very low and power losses decrease significantly.

I. MODELING

Many different objective functions can be considered for optimization. In this paper the difference between amplitude of three phase currents, in least square function form, is used as the objective function (similar to [1]).

KEYWORDS — Load balancing, Improved Leap-frog Method, Optimization algorithm, Low voltage distribution systems.

INTRODUCTION

Developing in distribution power systems, load variety and loads sensitivity have made distribution companies to pay special attention to power quality indices and networks reliability. One of the important topics in low voltage distribution systems is load reduction, in order to reduce the costs.

The existing low voltage distribution systems have various single, two and three phase loads. Optimum distribution of simple phase and double phase loads between three phases network is one of the important factors in reduction of the difference in the amplitude of loads between the three phases and power losses consequently.

In this paper a practical algorithm for load balancing in LV distribution networks in presented which is based on applying Modified Leap-frog Method to optimization of loads' connections to different phases subject to the fact that each single phase can be connected to one of the phases and the variable parameter which indicates this connectivity should remain as an integer number through and in final stage of optimization process.